ARPA ALPHA Annual Review 2016: Plasma Accelerator on SSX

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with contributions from

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ALPHA technical talk
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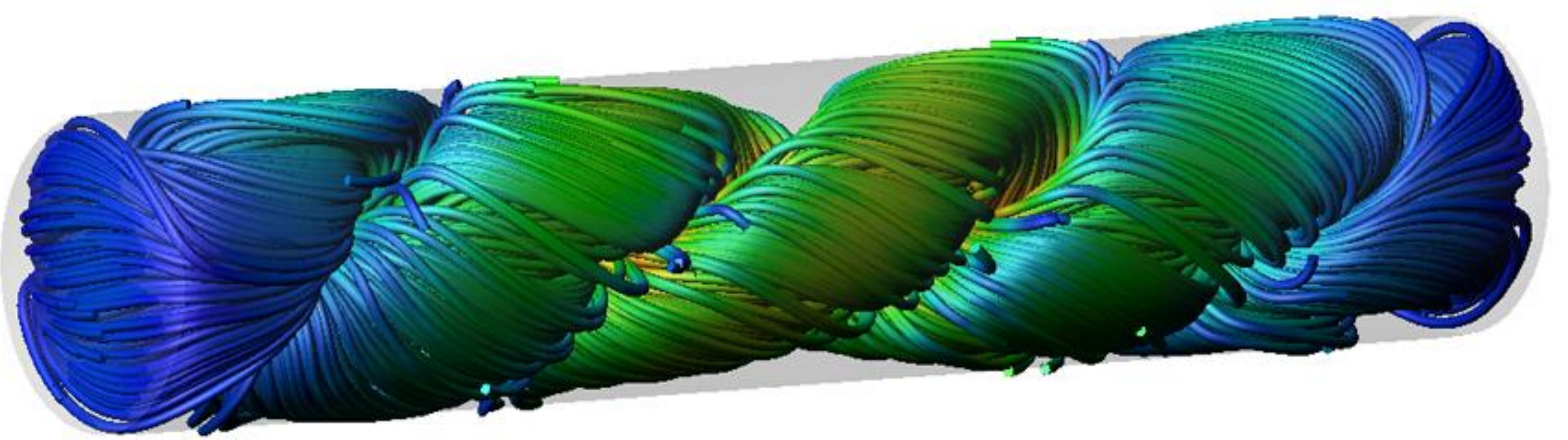
Our goal

- The twisted Taylor state is a magnetic plasma object, is the minimum energy state in MHD, and was discovered in the SSX lab in 2013 (Gray, et al, PRL)

- Our goal is to accelerate a Taylor state to high velocity, then stagnate and compress the object into a suitable MIF target



Overview of year one

- New postdoc Dr. Manjit Kaur is at SSX (May 2016)

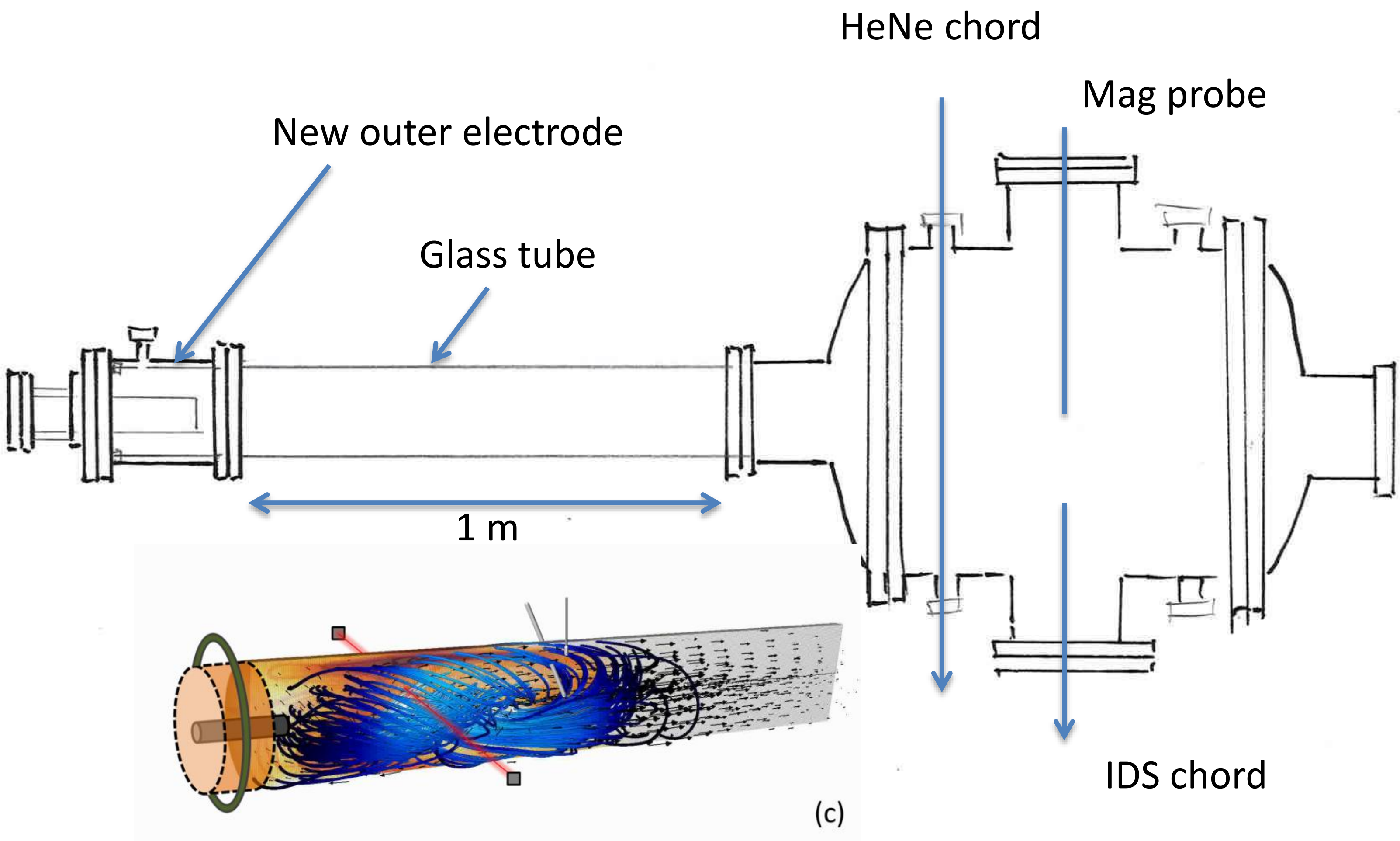
- Five new students: Jeremy Han ‘17 and Jaron Shrock ’18, Hayley Johnson ’18 BMC, Codie Fiedler-Kawaguchi ’18 BMC, Emmeline Douglas-Mann ‘18 BMC

- First SSX plasma in glass boundary, with various liners, flexibility for many experiments with quick turnaround and over 50 shots per day

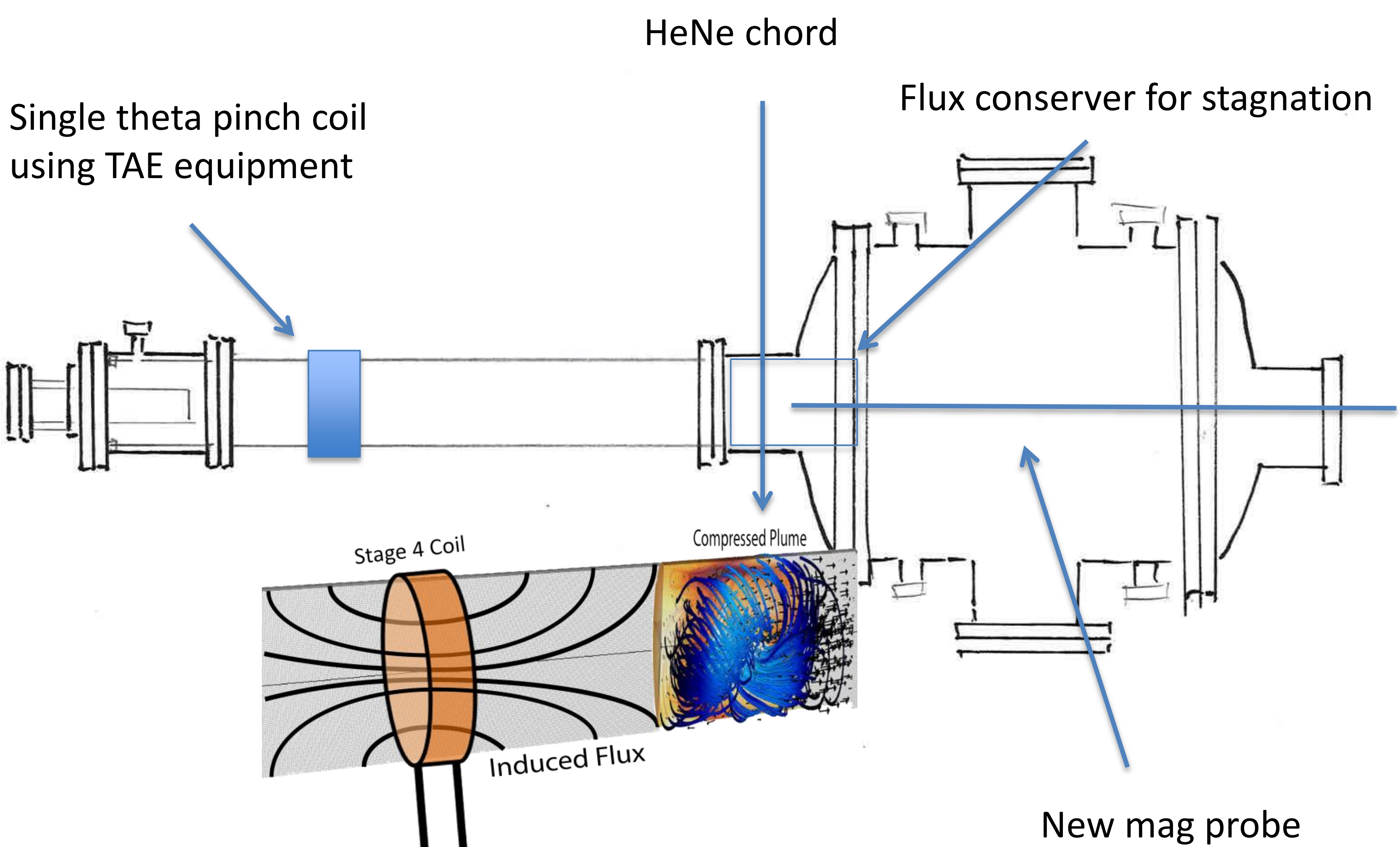
- Assembling high voltage test stand using TAE parts and new theta pinch coil

- $V = 30$ km/s, $n = 10^{15}$, $T_i = 30$ eV un-accelerated plume

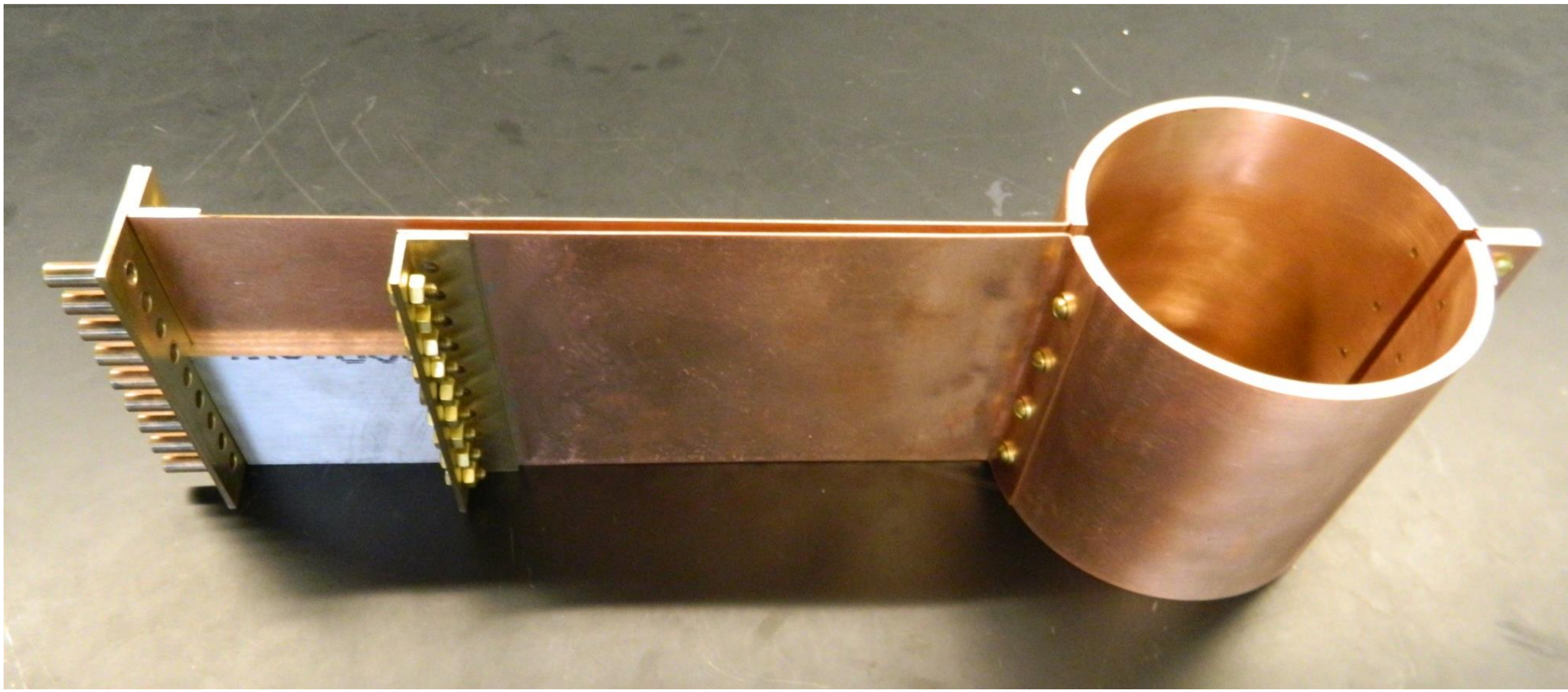
Experiments in early summer 2016



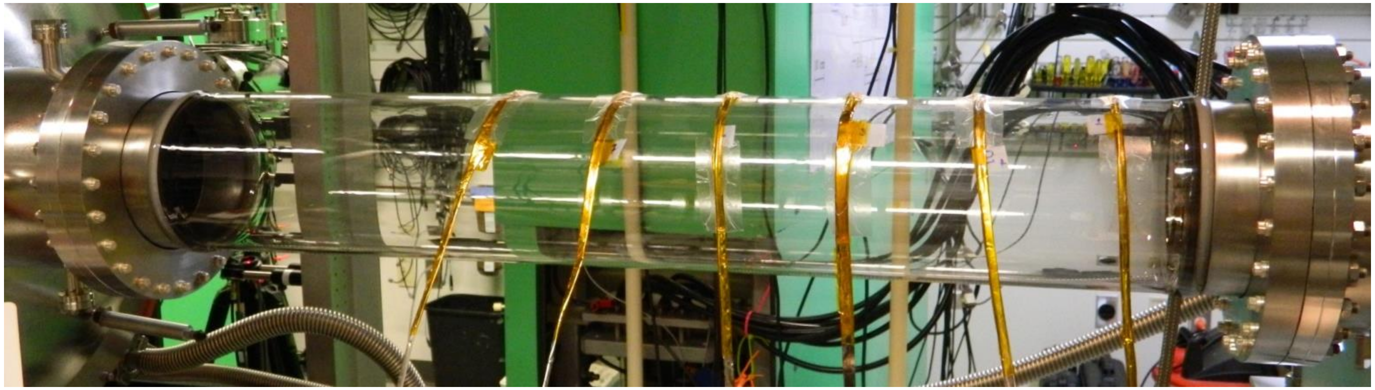
Next step fall 2016 (end of year one)



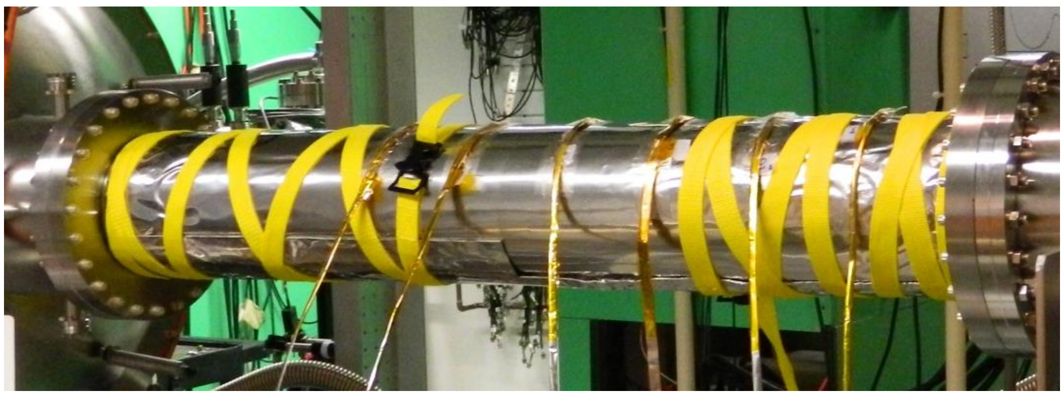
Accelerating theta pinch coil



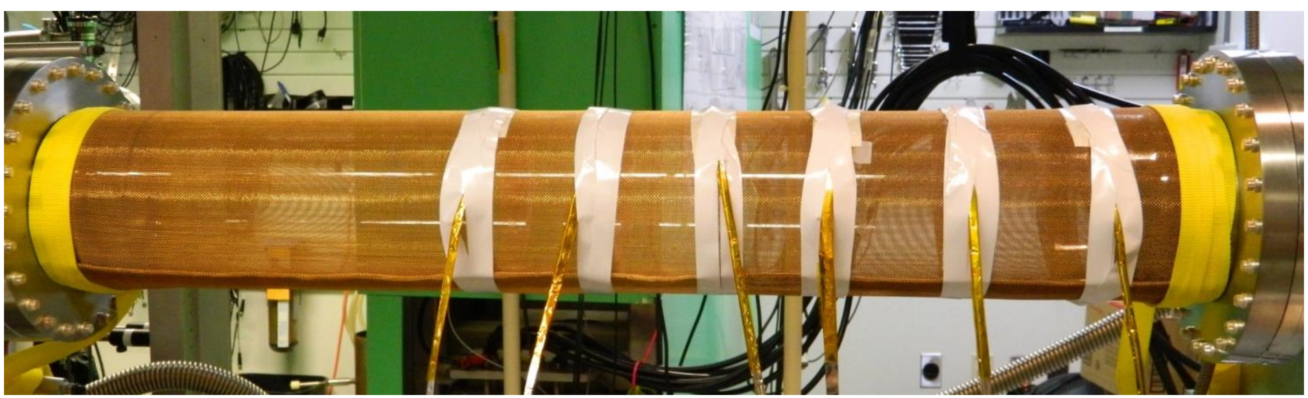
Three different boundary conditions



Glass Tube

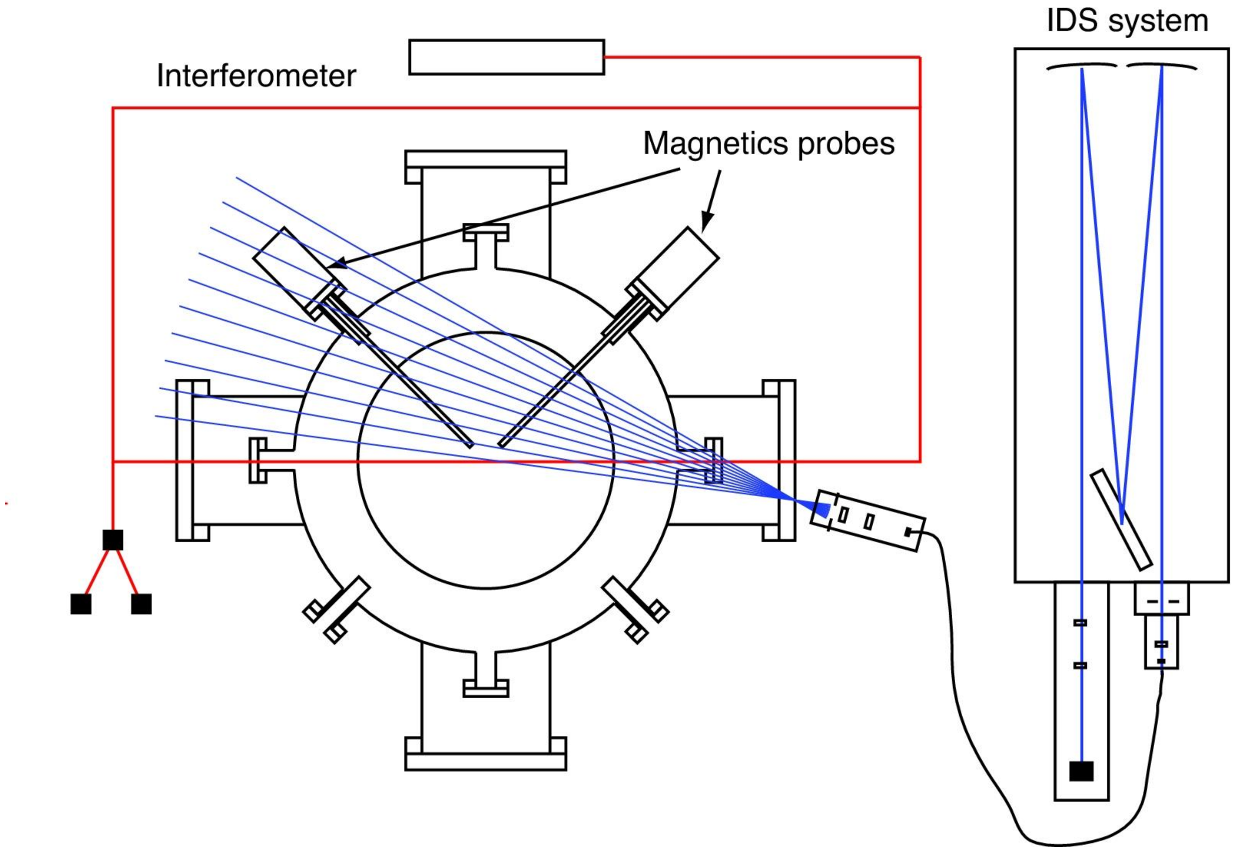


Resistive Liner



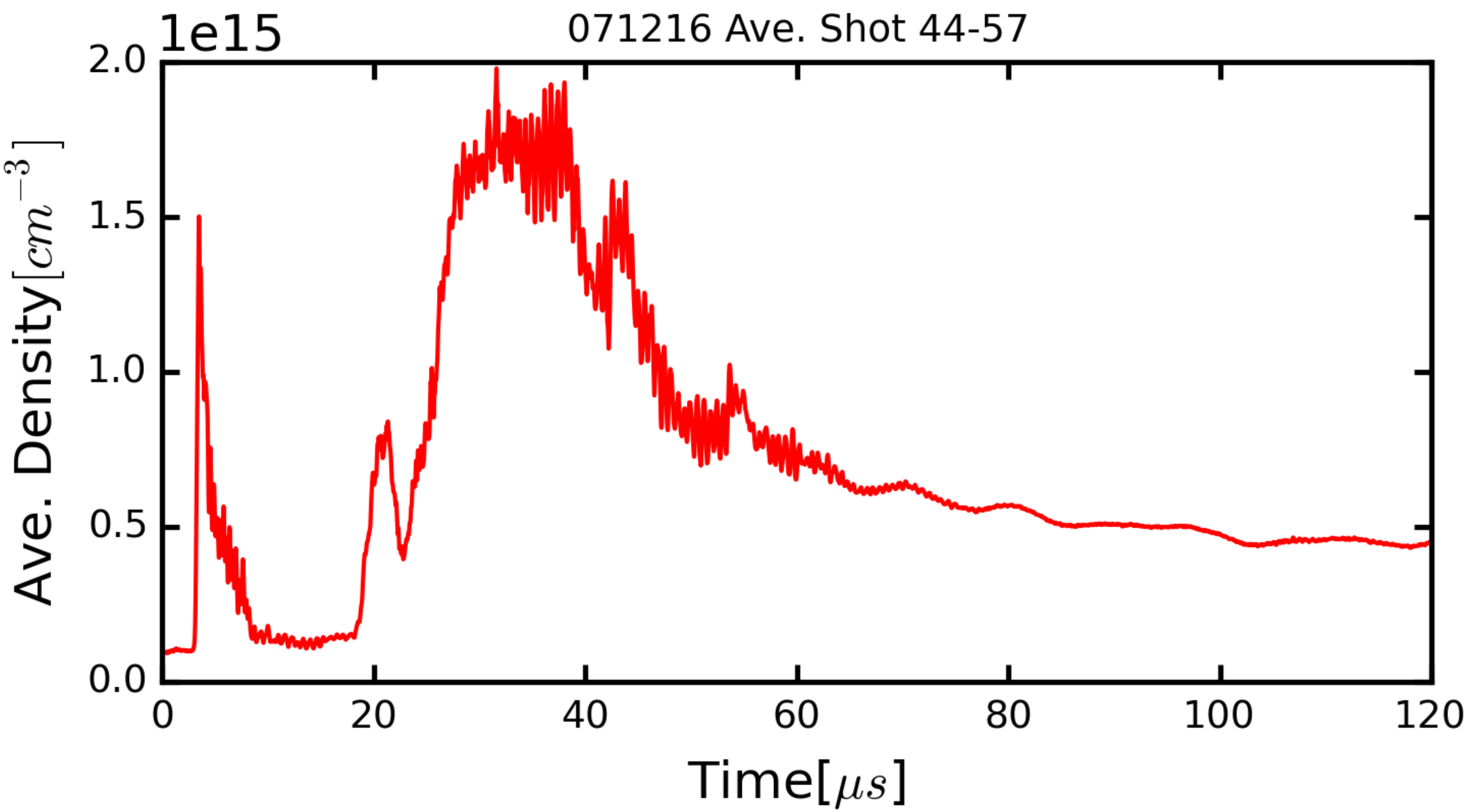
Mesh Flux Conserver

Ion Doppler spectrometer on SSX

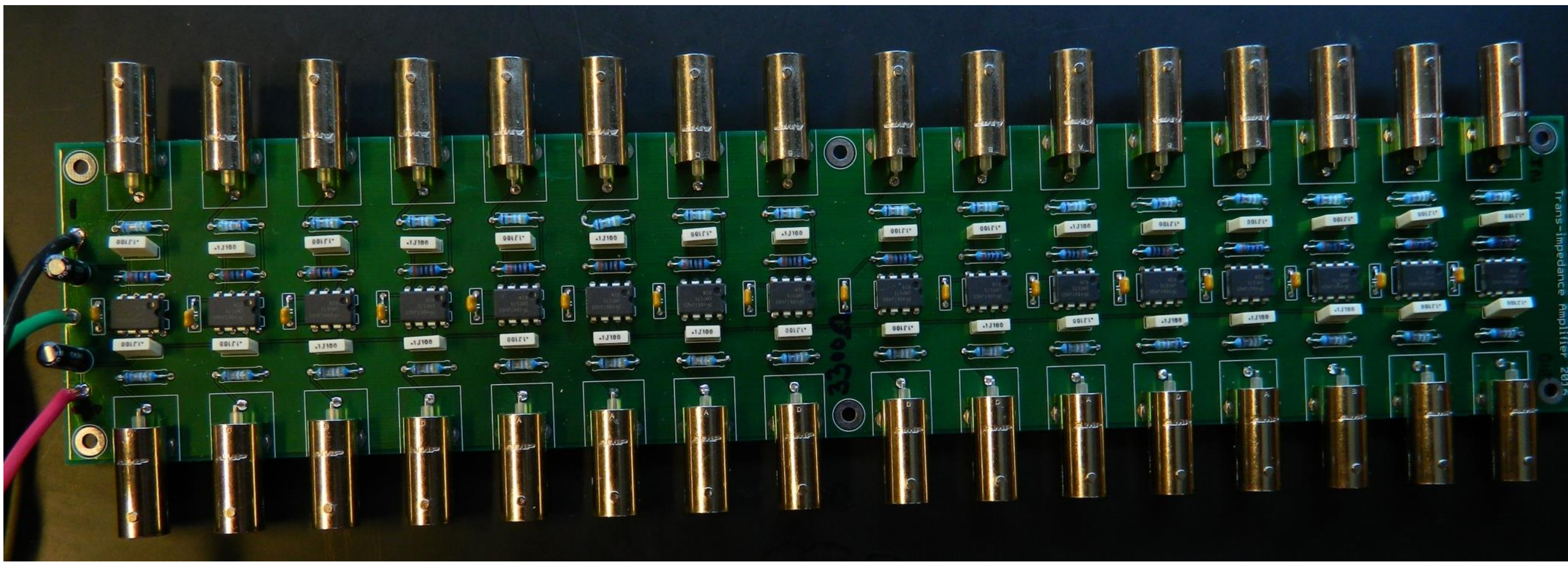


Interferometer chord and two magnetic probes also shown

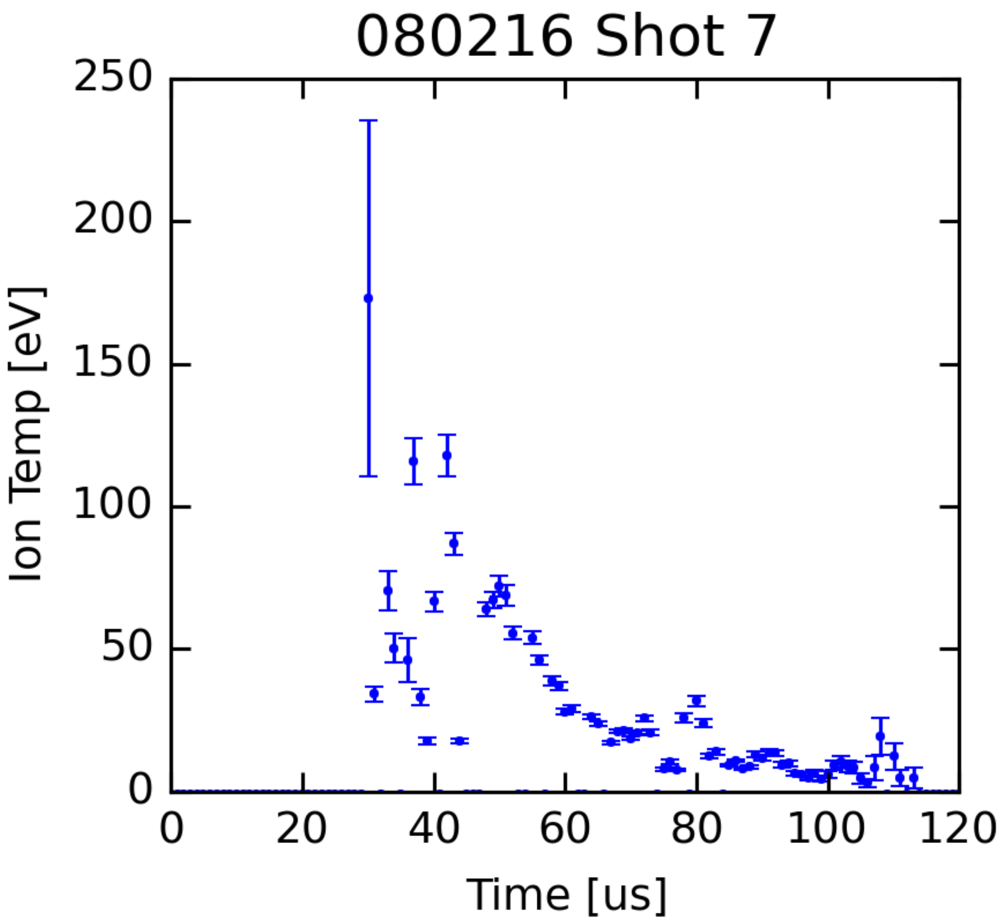
Density trace from glass



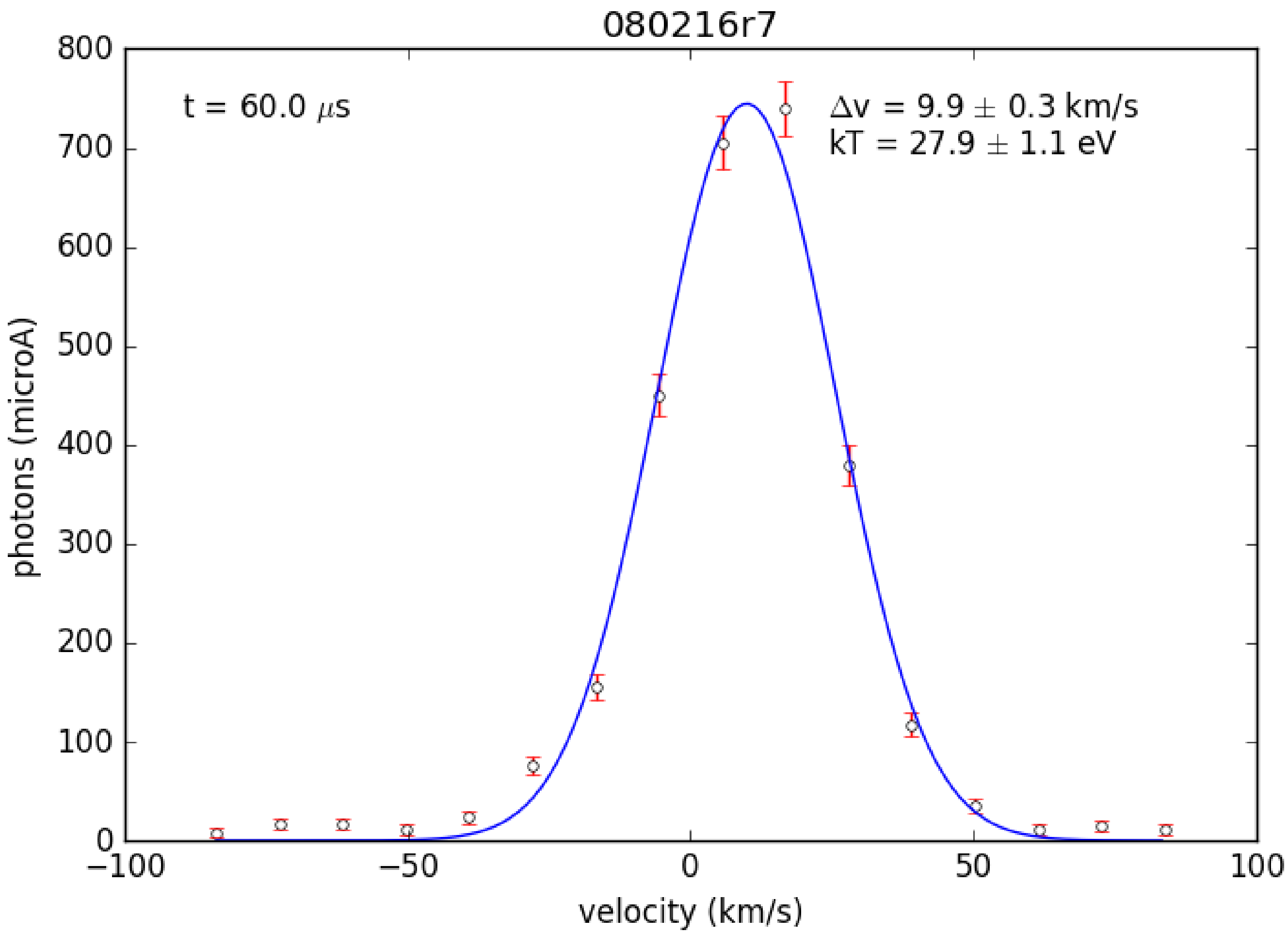
16-channel trans-impedance amplifier circuit



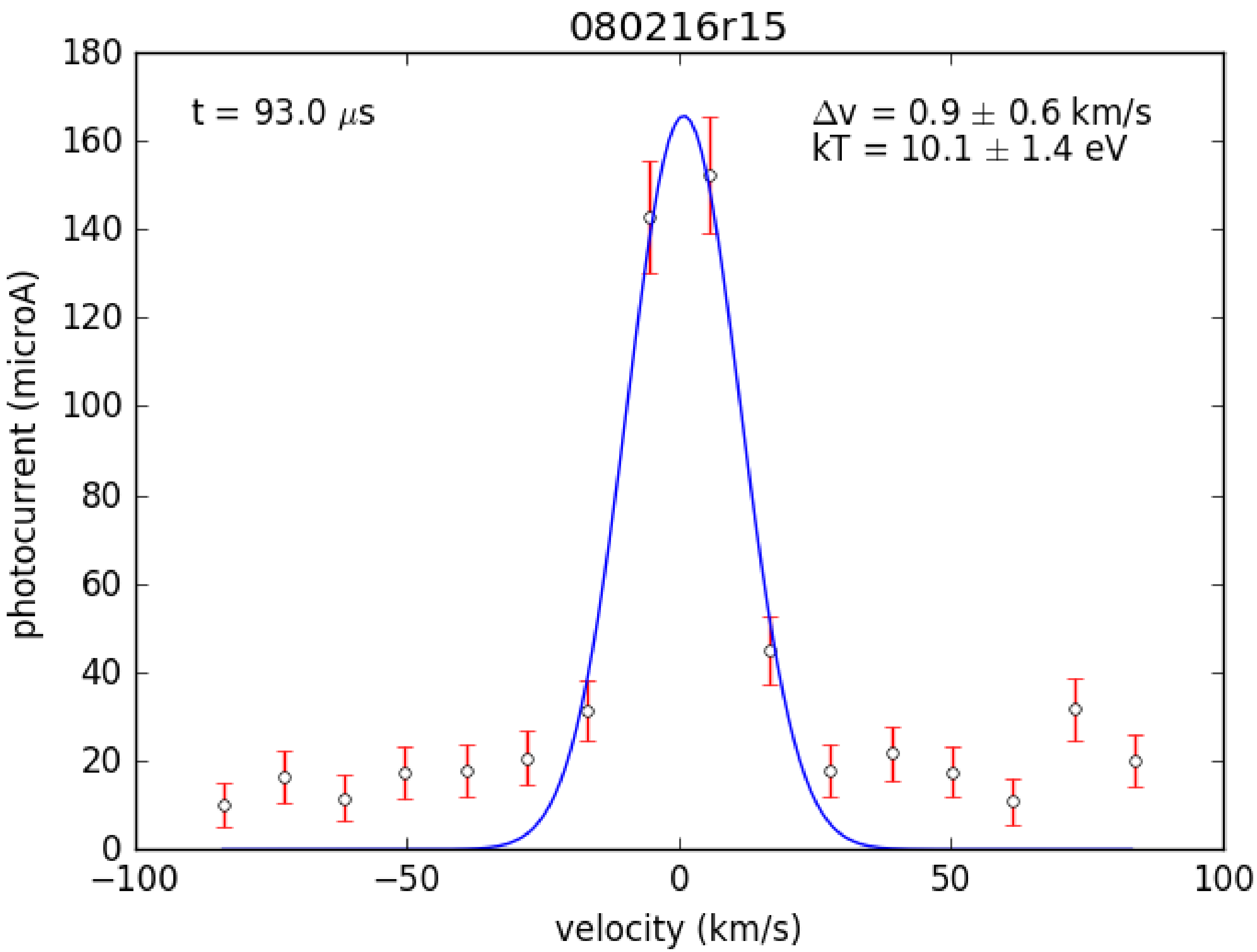
T_i from copper, single shot IDS



Line shape from copper

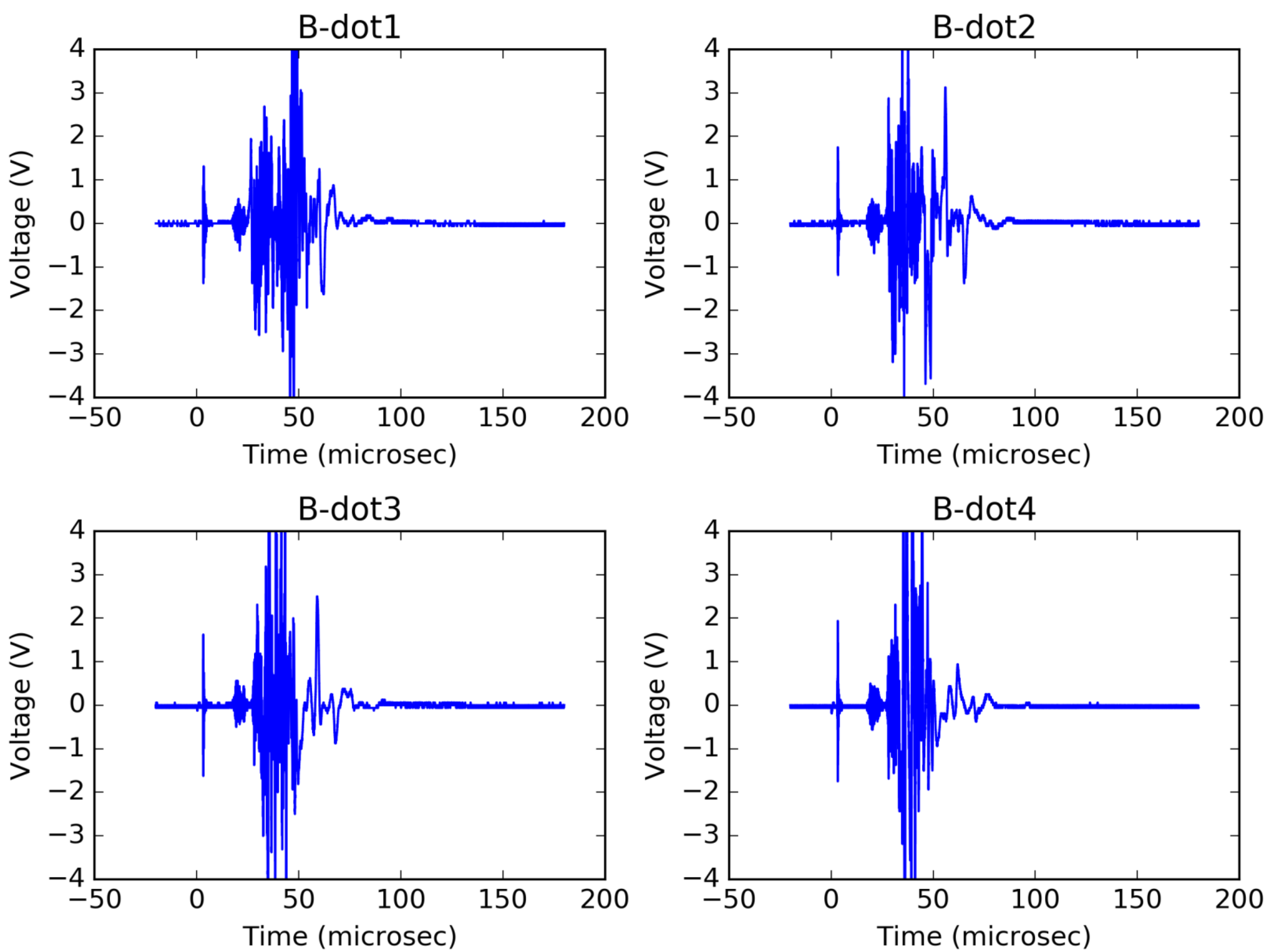


Line shape from glass



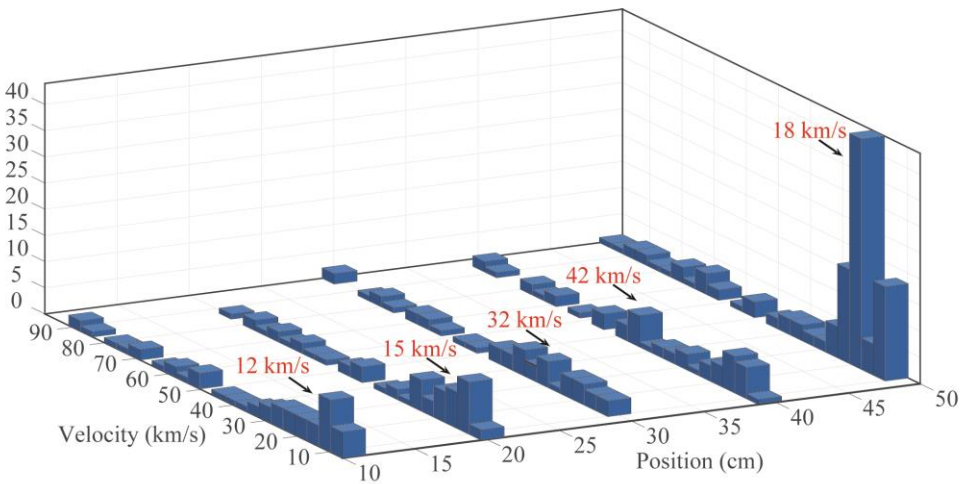
Time of flight measurements

Using probes single turn loops, 10 cm separation

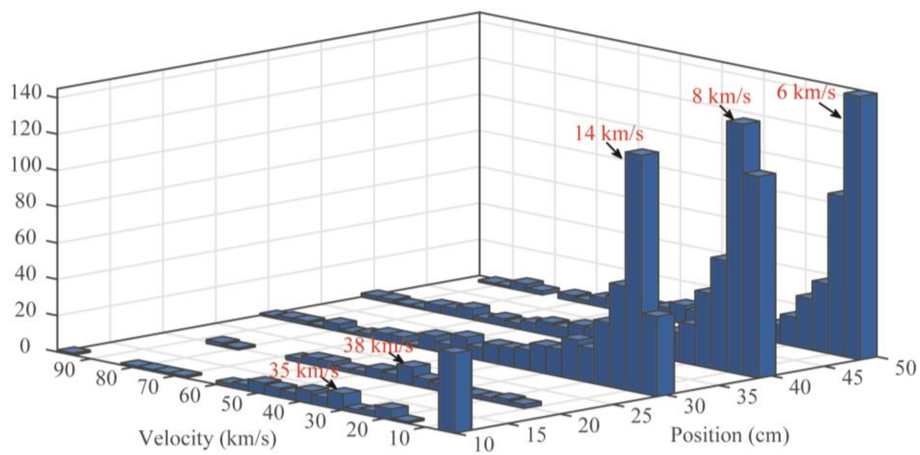


ToF with & without resistive liner

With Resistive Liner

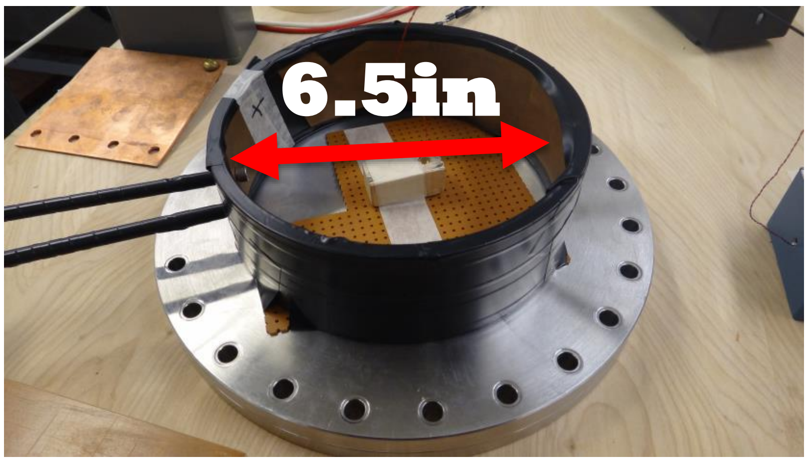


With Glass boundary

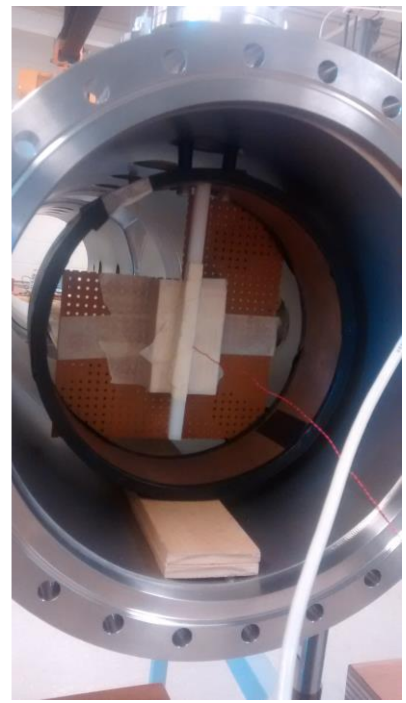


Measurements of Effect of Metal on Pulsed Coil (Bryn Mawr)

- Year 3 milestone: demonstration of coil ***inside*** a S.S. chamber
- Proof of Concept experiments conducted at Bryn Mawr College



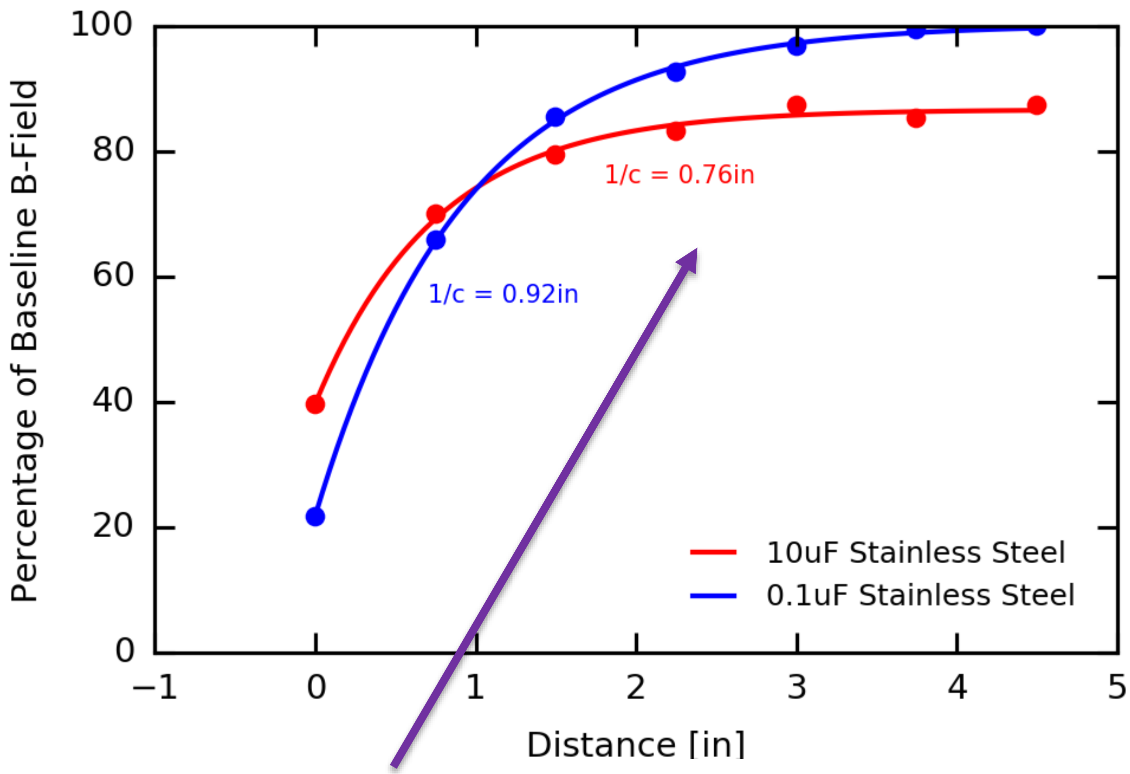
Effect of distance from a stainless steel plate on magnetic field signal of a pulsed coil



Measurement of pulsed coil magnetic field "in-situ"

Fast (w/0.1 μF cap) and Slow (w/10 μF cap) pulses tested with distance

- Fast pulses (~1 μs) recover all field
- Slow pulses (~20 μs) never fully recover
- **Little difference in recovery at <1in**



Field mostly recovered after ~3 in (~r_{coil})

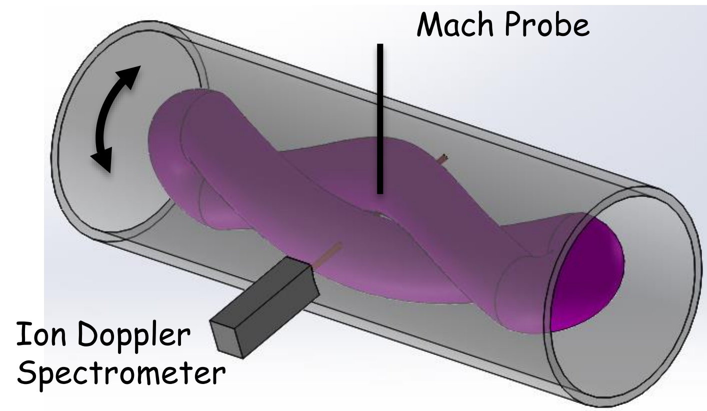
Exploring characters of the helix target

Though not focus of our proposal, we can explore characteristics of the Taylor state as a target

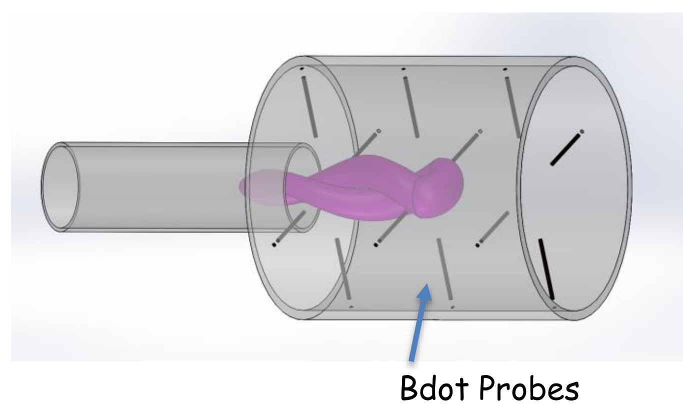
(many motivated by interaction with ALPHA members)

Examples:

1) What is the rotation behavior of the Taylor state?



2) What is the expansion time/stability of the Taylor state outside of a flux conserving boundary?



Review summary 2016

- Taylor state characterized in new glass extension with a variety of liners, ready for stagnation experiments

- Accelerator test stand (1 μF @ 20 kV) nearly ready using TAE equipment and new theta pinch coil